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PRELIMINARY STATEMENT CONCERNING A NEW SYSTEM OF QUATERNARY LAKES IN THE MISSISSIPPI BASIN[1]

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It is a significant fact that in but few places do the Mississippi and Ohio rivers flow on consolidated rock. Throughout most of their courses they flow over bodies of silt, sand, and gravel 50–100 feet in thickness. The lower half or third of each tributary also flows over a thick unconsolidated mass, which is similar to those on the larger streams, except that in general it is less coarse. For examples, the Wisconsin River in southwestern Wisconsin is working 50 feet or more above a hard rock channel; Big Muddy River in southern Illinois flows between mud banks in a broad, shallow valley with a buried channel 40 feet below; and away east in Pennsylvania the Monongahela does not flow over bed-rock at any point within the limits of the state. Thus, not only the valleys of the Mississippi and Ohio, but the lower part of almost every tributary valley in the northeast central states, and probably in a considerably larger territory, is partly filled with loose sediment, and in Illinois, Indiana, and Kentucky the filling on the tributary streams consists largely of clay, a brief description and interpretation of which are the objects of the present paper.

[1] Published by permission of the Director of the U.S. Geological Survey, Washington, D.C. A more complete description is to be published by the Ill. Geological Survey.

The upper surface of the clay forms a terrace which is generally so broad and so low that it is scarcely perceptible, though it is commonly separated from the flood-plain by a low scarp. This terrace is almost perfectly horizontal, and since the flood-plain rises up stream the terrace and flood-plain finally merge. However, since the flood-plain itself on the tributaries is nearly horizontal (for the streams have but little fall) the flood-plain and terrace on some rivers are distinct for 40 miles or more, although vertically they are almost nowhere more than 40 feet apart.

Another characteristic of these valleys is that in places they anastomose. Many valley floors connect through divides with neighboring valley floors. Some of the connecting parts are broad and resemble bays in the sea; others are narrow and strait-like; and the severed parts of the divide are massive. In many places the flat valley floor surrounds hills that stand up sharply like islands. These features of the lower parts of valleys tributary to the Mississippi and Ohio—the broad bottoms in hilly country, and the irregularly branching valleys—point toward valley filling. And well-sections and exposures support this indication, showing that bed-rock is far below the present streams.

Detailed description of the clay.—The clay varies from greenish-gray to purplish-gray in color and from medium plasticity to "gumbo." The lower part is evenly stratified and in places finely laminated. The upper part has less distinct stratification and is characterized by irregular concretionary masses of lime. Around the border and in the up-stream parts of the deposit there are lenses of fine sand, but considering the formation as a whole, sand forms a remarkably small part. With the exception of the concretionary lime, some particles of which are as small as sand grains, most of the deposit is without perceptible grit. In ground plan the bodies of clay are very irregular and even anastomosing—shapes that would be expected of valley fills in a country of medium to low relief (see Fig. 1). The surface of the clay in each valley is horizontal and lies from 5 to 75 feet above low water. But the altitude varies from valley to valley. Near Cairo the surface of the clay is 345 feet above sea; at Galena, Illinois, 400 miles up the Mississippi, it is 650 feet; and there is a corresponding

increase in altitude up the Ohio. Thus, although the deposit along each tributary and its branches is usually isolated and lies at a different altitude from that on every other stream, the different bodies have such a regular arrangement and have so many characters in common that there can be little question but that they are closely related, and they appear to be in large part lake deposits, but in smaller part stream deposits, so that they may be referred to as fluvio-lacustrine.

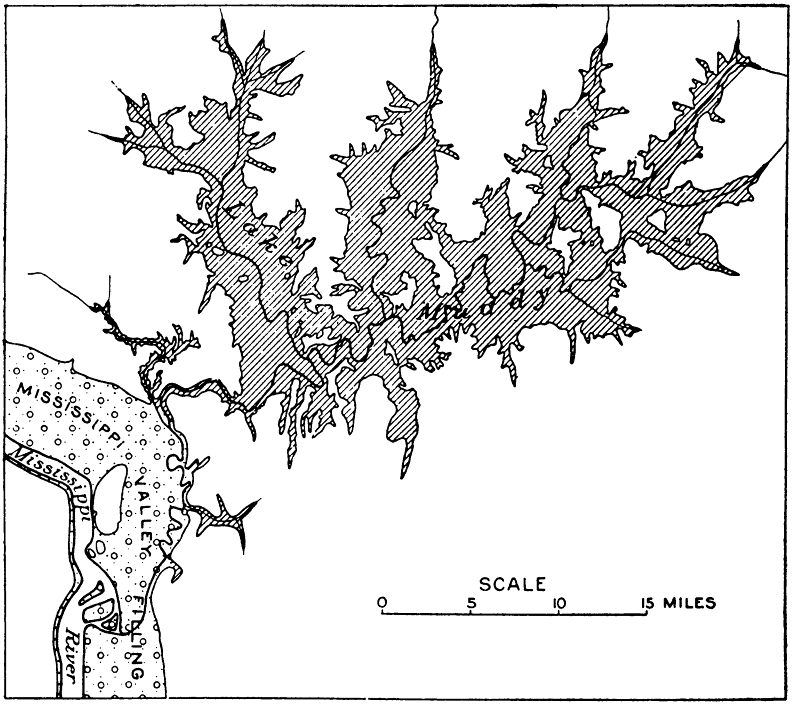

FIG. 1.—Lake Muddy, in southern Illinois. One of a series of lakes, now extinct, caused by a rapidly growing valley filling on the Mississippi and certain other streams, the filling forming a dam across the mouths of tributaries. The lakes stood at different altitudes, being controlled by the altitude of the Mississippi at their various outlets; each was in a continual state of fluctuation, the position of its surface at any moment being controlled by the stage of the Mississippi, and for a part of the time each was intermittent. The narrow part of Lake Muddy near the outlet was in a narrow, high-walled part of the valley, due to uplifted hard rocks. With the approach of every flood on the Mississippi water gushed up through the narrow part of the lake to the broader inland, a part carrying with it fine sand which, with interbedded lake silt, formed a delta at the *lower end* of the lake, fronting *toward the head* of the lake.

Shore features were generally poorly developed, though 12–15 miles northeast of Madisonville, Kentucky, 60 miles by water from the Ohio River, there are beautifully developed and well-preserved beach-ridges. These ridges are very symmetrical, being 20–50 feet wide, and 8 to 10 feet high (see Fig. 2). They are composed of sand and fine gravel and are situated across the mouths of small tributary valleys. The reason for the excellent development of gravel ridges at this place is the generous available supply of loosely cemented conglomerate, probably Late Tertiary in age, composed largely of well-rounded quartz and flint pebbles. Elsewhere there was not a large amount of well-rounded pebbles within reach of the lake and so far no other well-developed ridges have been found. At numerous places where the bank of the lake was easily eroded there is some suggestion of wave cutting, but the evidence has been almost obliterated by recent erosion. One reason for the general poor development of shore features is that owing to the rise and fall of the rivers the lakes were continually fluctuating and were intermittent for a part of the period of their existence. Thus, particularly in districts of low relief, the shores of the lakes did not stand in one position long enough to develop shore features.

Good collections of fossils were obtained, the fauna consisting of nearly a score of species of gastropods and lamellibranches, and undoubtedly many more species, including perhaps vertebrate and plant remains, might be found. Most of the forms collected inhabit lagoons and the quiet parts of streams. One of them (Campeloma) is a scavenger living in decaying animal matter. Others frequent lily ponds. Some, such as Vertigo, are northern forms, being found at present from Wisconsin northward.

The lime masses are probably secretions of blue-green algae, though at present they show little organic structure. They are more abundant in the thinner parts of the formation, and this may be correlated with the fact that lime-secreting algae flourish in very shallow or intermittent waters.

Previous work.—Bodies of this clay have been regarded as glacial drift; a lowland phase of the loess; an old normal flood-plain deposit; a back-water deposit from glacial floods on the larger

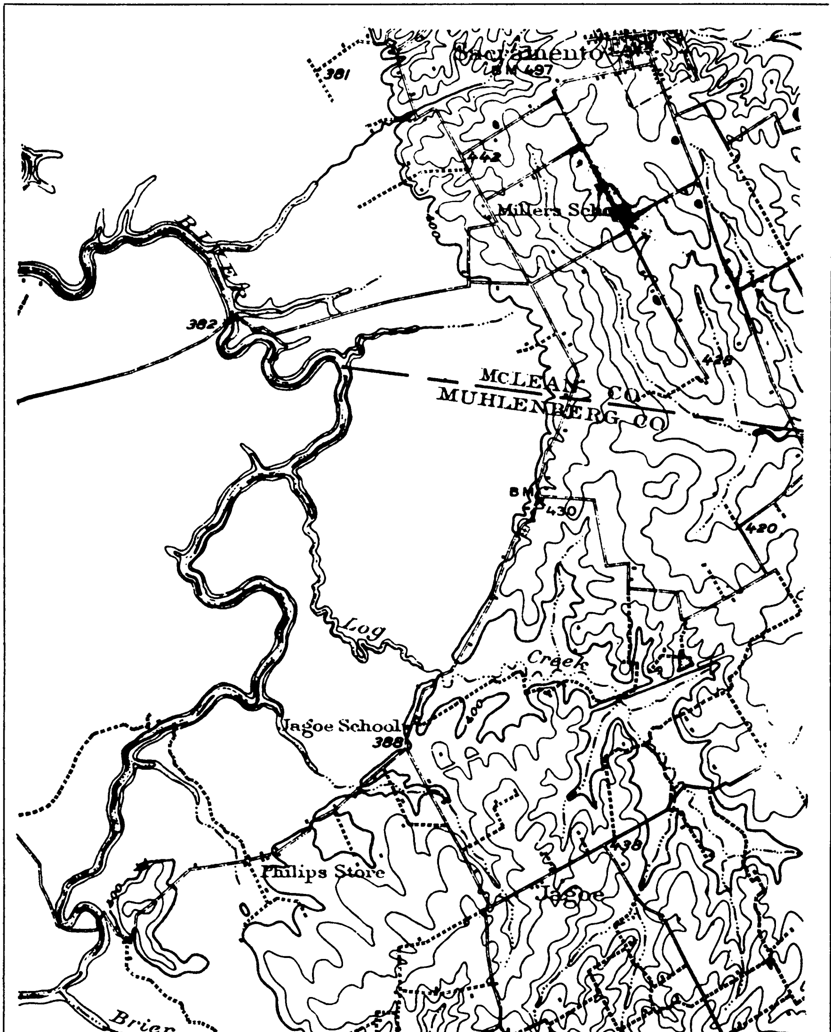

FIG. 2.—Part of Madisonville, Ky., topog. sheet, U.S. Geol. Survey, showing beach of extinct Green Lake (named from Green River which now drains the lake bed) and an "island hill." The thickness of the lake deposit here is about 30 feet and the surface 381 to 385 feet above sea. The "island hill" is one of many peculiar partly-buried hills which rise sharply from the flat surface of the material deposited around them so that they bear a strong resemblance to islands rising above a water surface. The beach ridge shows well in the topography between Philips' store and the McLean County line.

streams; a deposit due to subsidence; a deposit due to climatic change; and in southwestern Wisconsin a closely related but predominantly stream-laid deposit has been attributed to glacial floods and deposits in the Mississippi Valley.

The clay is not glacial drift, for it contains no stones and little sand; and much of it lies outside the glacial boundary. Moreover, it is found only in the lowest places and its upper surface is horizontal without regard to the underlying surface of hard rock. It is not loess, for it fills all depressions up to certain altitudes and is not found at higher positions. Its thickness and others of the characters already described show that it is not a normal flood-plain deposit. It could scarcely be a simple back-water deposit from glacial floods without the help of a valley train, because that would require that the rivers have a sustained depth of about two hundred feet for the thousands of years it must have taken the clay to accumulate. A subsidence of the surface might lead to the development of a few bodies of clay having the shape and arrangement of those under discussion, but warping so complex as to cause the regular arrangement and shape of so many bodies of clay would be inconceivable. Nor could the deposits have been produced by climatic change, for such deposits slope down stream and these are horizontal. Finally, the limited up-stream extent of the clay, the fineness of the material, the horizontality of the surface, and the fact that the clay abuts against thick bodies of coarser material on the large rivers, indicate that most of the clay accumulated in lakes produced by valley fillings, the master drainage lines of the region. In order to understand the cause and history of the lakes it is therefore necessary to look into the history of the large rivers.

Valley filling on the Mississippi and Ohio.—The deposits on the Mississippi and Ohio consist principally of sand, but there is considerable gravel and silt, the gravel being more abundant at the base and the silt at the top. Most of the material lies below extreme high-water stage, and hence the surface forms a flood-plain, but here and there bodies of sand and gravel stand about 30 feet above the reach of high water, the upper surface in such places forming a terrace at the altitude of the valley filling on near-by tributaries.

Apparently the river valleys were once filled to a position as high as the surface of the filling on the tributaries, but have now been partly cleared out, the surface of the fill being lowered about 30 feet. The part remaining is about 150 feet thick and extends about 120 feet below low water, the range between high- and low-water stages being about 30 feet (see Fig. 3).

In this connection it seems worth while to note that when the discharge of a stream is increased, the vertical distance between the bottom of the channel and the flood-plain is also increased, and this comes about not alone by scouring out the channel, but also by building up the alluvium. Thus, without any change in size of load, it is possible to produce thick alluvium by simply increasing the volume of water.

To return to the lakes themselves: they differed from most bodies of quiet water in that the position of the surface varied greatly every year, for it was controlled by the various stages of the rivers. If the range between high and low water had been the same that it is now the surfaces of the lakes would have fluctuated between limits about 10 to 40 feet apart. But the lakes formed a huge reservoir so that with the same discharge as at present the rivers would not have risen nearly so much in times of flood.

Indeed, to raise the surface of the lakes and rivers one foot, it took over one hundred billion cubic feet or nearly a cubic mile of water; moreover, every rise of 5 or 10 feet would double the discharge of the rivers, so that tremendous floods could be taken care of without great increase in depth of water.

Terminology.—It seems probable that the rather extensive development of deposits and resulting topographic features such as are described in this paper will lead to the introduction of some new descriptive terms. Perhaps it will be found convenient to use "contragradation" or "dam gradation" for that kind of stream aggradation which is caused by an obstruction, or, more broadly, decrease in velocity, and perhaps to invent still other terms for the aggradation due to increase in load and decrease in volume. In case the obstruction develops so rapidly as to produce ponded water, such as is described in the present paper, the deposit is on the whole very fine-grained and the top nearly horizontal though

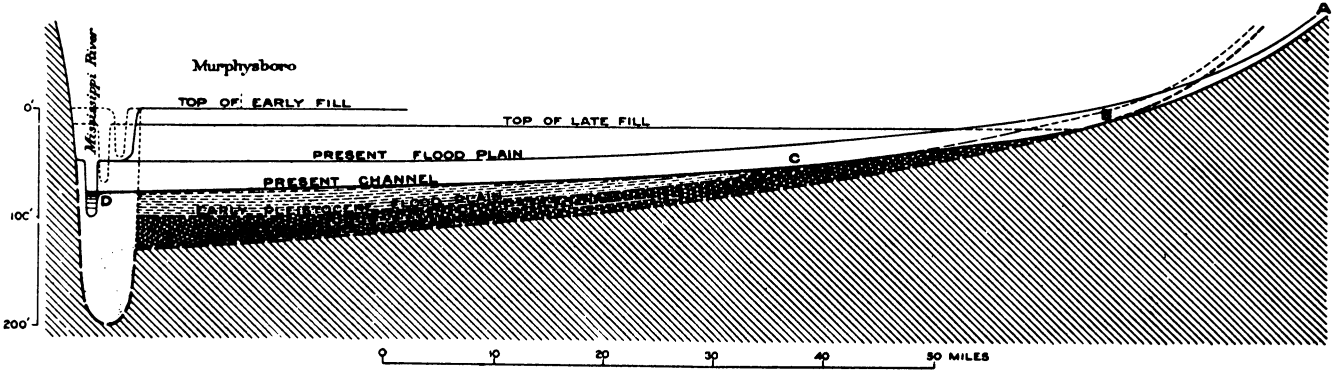

FIG. 3.—Longitudinal section of Muddy River deposits and cross-section of Mississippi River deposits. The filling material in Muddy River Valley, like that in many others, is for the most part very fine-grained silt and clay, in part fluvial and in part lacustrine. There seem to be two different fillings, and the top of each is horizontal. The lower part of the present flood-plain is horizontal and high above the present channel bottom, the distance being controlled by the range between high and low water on the Mississippi as far as back water from that stream reaches. The present profile reflects the history of the stream, the fall from A to B being moderate, B to C low, and C to D extremely low. The bed-rock profile of Muddy Valley is not adjusted to that of the Mississippi Valley, indicating a rapid deepening (Pleistocene?) of the Mississippi Valley. In order to show the profiles correctly the section was made on the whole course of Muddy River and not in a direct line from the source to the mouth.

more or less concave. For the resulting topographic feature, the bottom of Muddy River Valley may be taken as a type and *Muddy* may be an acceptable name for it, referring, as the name does, both to a particular type and to a principal character of the deposit, and the streams which flow over it, and also to the general character of the country where the feature is developed. On the other hand, in case aggradation keeps pace with the growth of the dam the material is in general coarser and the upper surface rises up stream, though at a less rate than the original stream channel. For this topographic feature the surface of the deposit forming a low terrace along Big Sandy River in eastern Kentucky may be taken as a type and called a *Sandy*. Perhaps also it will be found desirable to speak of the island-like hills surrounded by the deposit as *Island Hills*, and the hill bearing the town of Island, in Kentucky, may be taken as a type.

Summarizing.—The inferred history of the lake deposit reads about as follows: In middle or late glacial time the rivers were flowing on beds about 100 feet below their present ones. Whether this great depth was attained in an interglacial epoch by a regional uplift or was reached through the deep scouring of glacial floods has not yet been determined. The tributaries entered the flood-plains of the Mississippi and Ohio on channel bottoms only about 40 feet lower than those in use today and their flood-plains were near the position of their present channel bottoms, these positions being controlled by low- and high-water stages on the master streams. As at present, at low-water stage there was no standing water in the tributaries, but at high water the deep channels were filled by back water from the rivers, thus forming long, narrow winding lakes. When aggradation began on the Mississippi and Ohio, both low- and high-water marks on them and on the tributaries rose. At low water there were embryo, perennial lakes in the channels of the tributaries at their mouths and at high water the flood-plains were covered more deeply than before. The area covered both at low- and high-water stages gradually extended until low-water stage reached the altitude of the former flood-plain. From this time on there were perennial bodies of quiet water of considerable size on each tributary, and wedge-shaped masses of

lake deposit about 80 feet thick at the lower ends and thinning out to a feather edge up stream, accumulated on the old flood-plains.

Nearly all the material deposited in the lakes was fine sediment such as would be carried in suspension, and the lakes seem to have been filled with this material up to certain concordant positions, probably to the natural position of a flood-plain or just below the high-water mark of the time.

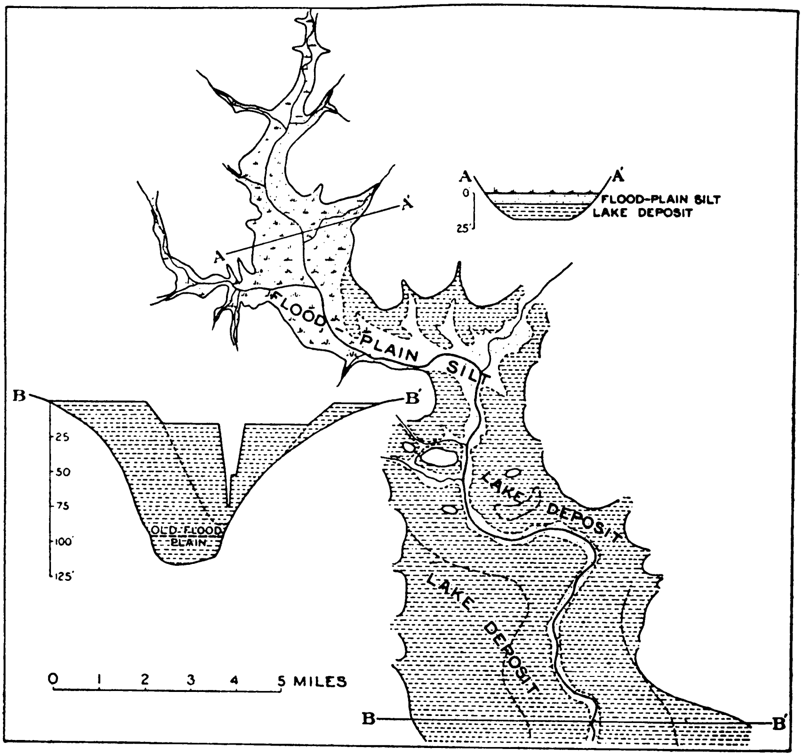

FIG. 4.—Diagram showing arrangement of principal deposits and surface features along Beaucoup Creek, Perry and Jackson counties, Illinois. The filling thickens and the flood-plain becomes narrower down stream. When the lake became extinct the bed became a great swamp. The stream first cut into the lower end of the fill, draining that part of the swamp and developing a narrow flood-plain below the surface of the lake silt. With further downward cutting the new flood-plain was lowered and extended up stream and the swamp area reduced. Meanwhile, stream deposits continued to accumulate at the upper end of the lake bed. Many other valley bottoms are similar, having a peculiar swampy central portion.

When the Mississippi and Ohio finally became not only able to carry all the load delivered to them but a little more, they began to cut down again. Perhaps even before this time the lakes had become intermittent, being drained except at times of high water, for they were almost filled with sediment. The great flat lake bottoms became swamps, and channels began to deepen again at the former outlets. At the same time the swamps themselves began to be drained at the lower ends. The process of swamp draining has continued to the present time, and on medium-sized streams there now remain only 10–20 miles of swamp, the lower 20–50 miles having been drained (see Fig 4).